

SHARPE (N.W.)

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PECULIARITIES AND TREATMENT OF
ELECTRIC INJURIES.

BY

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PECULIARITIES AND TREATMENT OF ELECTRIC INJURIES.

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Surgeon to the Wagner Electric Manufacturing Co. ; to the Missouri Electric Light and Power Co. ; and to the Edison Illuminating Co.

IT would be manifestly gratuitous in an article of this character to permit the conventional introduction, to cite a list of cases, and to offer a more or less elaborate explanatory discussion of the theme in hand. Certain information and data are taken for granted. Conversance with elementary electric phraseology, terminology and formulæ is presupposed. Yet it would be well for us to bear in mind the following facts:

The alternating and direct currents are the forms most often employed to-day for commercial purposes. The former supplies incandescent-lighting systems, requiring voltage from 1,600 to 2,000; the latter is used in arc-lighting systems, and as motive-power in railways, factories, etc., requiring voltage ranging from 500 to 3,000. The lethal force of electricity is almost entirely dependent upon voltage or electro-motive force, being actually the result of the current in ampères which is caused to flow through the body, against its resistance, by the electro-motive force. There are cases on record in which a pressure of 500 volts has proved lethal, but by far the greater number of fatalities have been produced by pressure exceeding 1,000 volts. From 1,500 to 2,500 volts have been employed in electrocution, the skin-resistance brought to the minimum by contact-sponges, of large surface wet with saline solution.

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Of the various human tissues, the skin presents the highest resistance to electric penetration; different thicknesses produce resistance of varying degree. When it is removed, destruction is markedly intensified. Skin-resistance is increased by dryness; when moistened, especially by saline solution, it is notably diminished. Experience tends to show that a current of one or two amperes is fatal to the majority of individuals. The fact that comparatively low voltages in some cases have proved fatal, and victims of shock from relatively high voltages have recovered, does not necessarily show that some systems can withstand more current than others, but rather that the skin-resistance was greater, or the area of contact smaller, or drier, in the more fortunate cases (according to Ohm's law).

Any current sent through the body being dependent upon resistance offered (the skin remaining the chief factor), it follows that the larger the area of contact, the less resistance, and a proportionally greater amount of current is received. It has been proved that a 2 % or 3 % saline solution offers a resistance equal to about $\frac{1}{20}$ of that of pure water, and that sea-water offers about $\frac{1}{40}$. It is also known that a resistance of 80 ohms—60°, is offered to an alternating current by a cubic foot of pure water at 60° F., while a cubic foot of pure water plus $\frac{1.5}{100}$ pounds of rock-salt produces but 7 ohms resistance to the same current. Permit these waters to be elevated to 212° F., and we find that pure water resists to the extent of 24 ohms, the saline solution to but $4\frac{2}{10}$ ohms. From these and other data we are justified in deducing that—1. The salinity of the sweat; 2. Temperature; 3. Atmospheric humidity; 4. Season of the year, are all important determinant factors in the intensity and gravity of trauma and shock due to electricity. It is of value to add that of the two more important and ordinarily utilized currents, the

direct has the greater electrolytic intensity, while from the alternating we have failed to discover any permanent chemic change. In cases of fatal exposure to either current, sudden and profound shocking of the sympathetic system is, without doubt, the lethal agency.

Electricity produces traumata, ranging from insignificant burns to death, of which an overwhelming percentage consists of burns. They occur, as do all other traumata, upon the most exposed portions of the body, and differ from ordinary burns or scalds in—1. Appearance; 2. Accompanying pain; 3. Concomitant shock; 4. Prognosis; 5. Subsequent manifestations; 6. Reaction to treatment; and frequently, 7. Result.

1. *Appearance.* The majority of electric burns, seen early, present a dry, crisped aspect, excavated and bloodless, with a surrounding zone characterized by pallor. This condition changes within 36 hours; serous oozing obtains, the tissues soften, and hyperemia replaces the pallor.

2. *Pain* is, as a rule, very moderate, in some cases practically absent; from 24 to 48 hours after contact it is usually present.

3. *Shock.* Electric burns differ from other burns, in that the systemic shock is from the contact—the shock from the burn, *per se*, being *nil*.

4. *Prognosis.* In regard to time, electric burns average from $1\frac{1}{2}$ to 3 times as long in recovery as do other burns. In severe cases, dependent upon locality, such as proximity to bones and joints, the ratio is as five, or more, to one. Prognosis of result is as uncertain as time-prognosis; severe cases may progress relatively rapidly; mild cases are often persistently rebellious to recovery; usually both mild and severe cases are tedious and prolonged.

5. *Subsequent Manifestations.* The rule of the electric burn, to which there are rare exceptions, is that it

changes within 36 hours from contact to a serum-saturated area, with disintegrating walls and floor, progressing to profuse purulent secretion, with continued tissue-degeneration. This degeneration will frequently involve nerve, muscle, tendon, joint-capsule, ligaments, articular surfaces, periosteum, and bone itself; exuberant granulations springing up, the entire plain bathed in pus, complete a picture alike distressing to patient and surgeon.

6. *Reaction to Treatment* is very unsatisfactory, it being an apparent impossibility to check the disorganizing process, especially in severe cases, with most scrupulous antisepsis or asepsis. After a varying period of from 15 to 50 or 60 days, and often much longer, firm granulation will slowly proceed; and

7. *The Result* will be as good as is ordinarily secured in other burns. In some cases, however, owing to the disintegrating process involving bones and joints and producing necrotic masses, amputation is necessary.

Too much stress cannot be laid upon the foregoing clinical picture, and errors in prognosis are readily made by those who have not been brought in contact with such injuries, in regard to time and result.

The sloughing almost invariably present is noteworthy. Frequently a burn, which in its incipient measurements will not occupy more than a square inch of surface, will produce a subsequent area of four or five square inches or more, due to degenerative changes. The intensity and persistence of this process, unabated by usual surgical methods, can only be accounted for by a local trophic death, produced by electrolytic activity in destruction. This wet gangrene continues as long as the local trophic inanition lasts, and healthful rejection of sloughs, and replacement by firm granulation-material, cannot, and do not, obtain until local trophic equilibrium is again established.

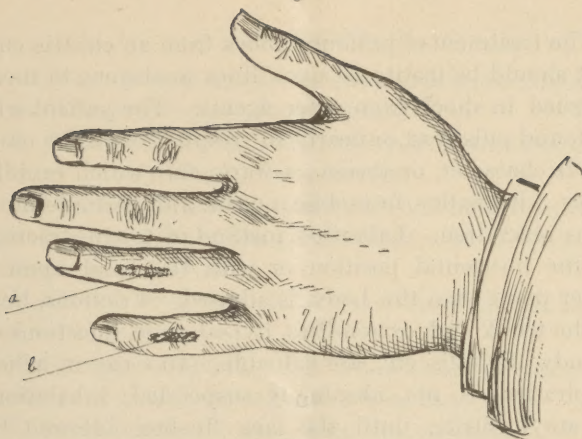


Fig. 1.

a and *b*. Points of contact in an electric wire burn (crisped and bloodless).

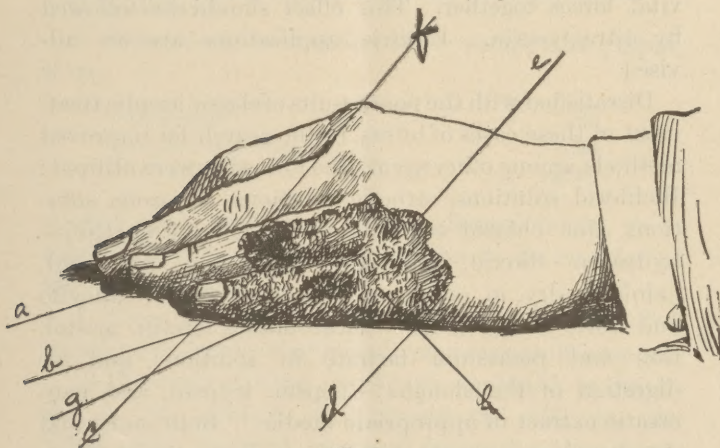


Fig. 2.

a and *b*. Sites of original contact. *c*, *d*, *e*, and *f*. Peripheral excavated walls of a plain, suppurative and degenerative in character. *g*. Necrotic first inter-phalangeal articulation, involving also first and second phalanges. *h*. Fourth metacarpo-phalangeal articulation, site of subsequent amputation.

Figure 1 represents the condition of a hand immediately after contact with the electric wire.

Figure 2 represents the same hand from 30 to 50 days after contact.

Injury—burns of third and fourth fingers; cause—electric wire-contact; current—alternating; duration of injury—between 60 and 70 days; remarks—suppuration and sloughing involved first inter-phalangeal articulation and first and second phalanges of fourth finger, necrosis followed; degeneration extended rapidly and deeply over both palmar and dorsal surfaces, amputation at fourth metacarpo-phalangeal articulation; result—marked cicatrization, otherwise good.

The treatment of profound shock from an electric current should be instituted upon lines analagous to those pursued in shock from other agents. The patient will be found pulseless, or nearly so; respiration of the most feeble character, or absent; a warm skin which rapidly cools, with pallor, immobile pupils, and absolute muscular relaxation. Laborde's method of tongue-traction in the horizontal position, or with the head upon a lower plane than the body, is advised. Frictions, heat to the trunk and extremities, hypodermic injections of brandy, digitalis, etc., are valuable. In cases in which respiration is not absolutely suspended, inhalations of amyl nitrite, until the face flushes, followed by a massive hypodermic of strychnin, will bring the vital forces together. This effect should be followed by nitroglycerin. Electric applications are *not* advised.

Dissatisfied with the poor results of classic aseptic treatment of these cases of burns, in the search for improved methods, among other agents, the following were utilized: Bichlorid solutions, carbolic solutions, pyrozone solutions, zinc chlorid solutions—in varying strengths;—hydrogen dioxid, sterilized water, hot and cold, iodoform, dry, in emulsion, and in glycerin; salicylic and boric acids; sodium bicarbonate, loretin, aristol, iron and potassium tartrate in solution; and for digestion of the sloughs:—pepsin, trypsin, and pancreatic extract in appropriate media. Both moist and dry dressings were employed in various cases. These agents yielded results practically analogous to the conventional aseptic and antiseptic measures of wound treatment; in some cases the results were not as satisfactory. They should be employed as adjuvants, fitted to the demands of the individual case, to aseptic or antiseptic means, and not as substitutes.

CONCLUSIONS.

1. The skin is the chief factor of resistance in an individual sustaining an electric shock.

2. Moisture of the skin, and especially marked salinity of sweat, favors access of the current.

3. Humidity and temperature of the atmosphere, and season of the year, are important factors in determining individual resistance.

4. Electric traumata differ from ordinary burns or scalds in duration.

5. Electric traumata differ from ordinary burns or scalds in results (noticeable in severe cases).

6. Prognosis in all cases should be guarded.

7. Rigid asepsis should be followed in the manipulation of all cases.

8. Sloughs are best removed by solution of pepsin, thus :

Scale pepsin	2.00
Hydrochloric acid, U. S. P.	1.00
Distilled water	120.00—

washed off in two hours with hydrogen dioxid, pyrozone, or hydrozone; the application to be repeated as may be necessary.

9. Deep disintegration demands especial watchfulness for the detection of bone-invasion or joint-invasion.

10. Necrosis of bone should be combated by injecting a 3% solution of hydrochloric acid, in distilled water, repeated not more frequently than every two hours. Every second day the acid-pepsin solution (see above) should be used, until the necrotic masses are cleared away, when gauze-packing should follow. In cases complicated by tuberculosis a 10% solution of iodoform in ether should be subsequently employed.

11. Persistent bone-invasion or joint-invasion, with

necrosis, requires amputation, or, in some cases, resection.

12. Degenerative division of important nerves should be subsequently repaired by Levering's method ; degenerative division of important arteries and veins should be repaired by Murphy's method, when possible.

13. Granulating areas, after sterilization, should, when feasible, be covered by large skin-flaps.

14. When the healing-process has started, peripheral skin-growth is hastened by the use of a layer of sterile gauze saturated with an iodoform-glycerin mixture, covered by rubber tissue.

15. For the treatment of profound shock Laborde's method of tongue-traction, application of heat and frictions, inhalations of amyl nitrite, massive hypodermics of strychnin, and nitroglycerin internally, are recommended.

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